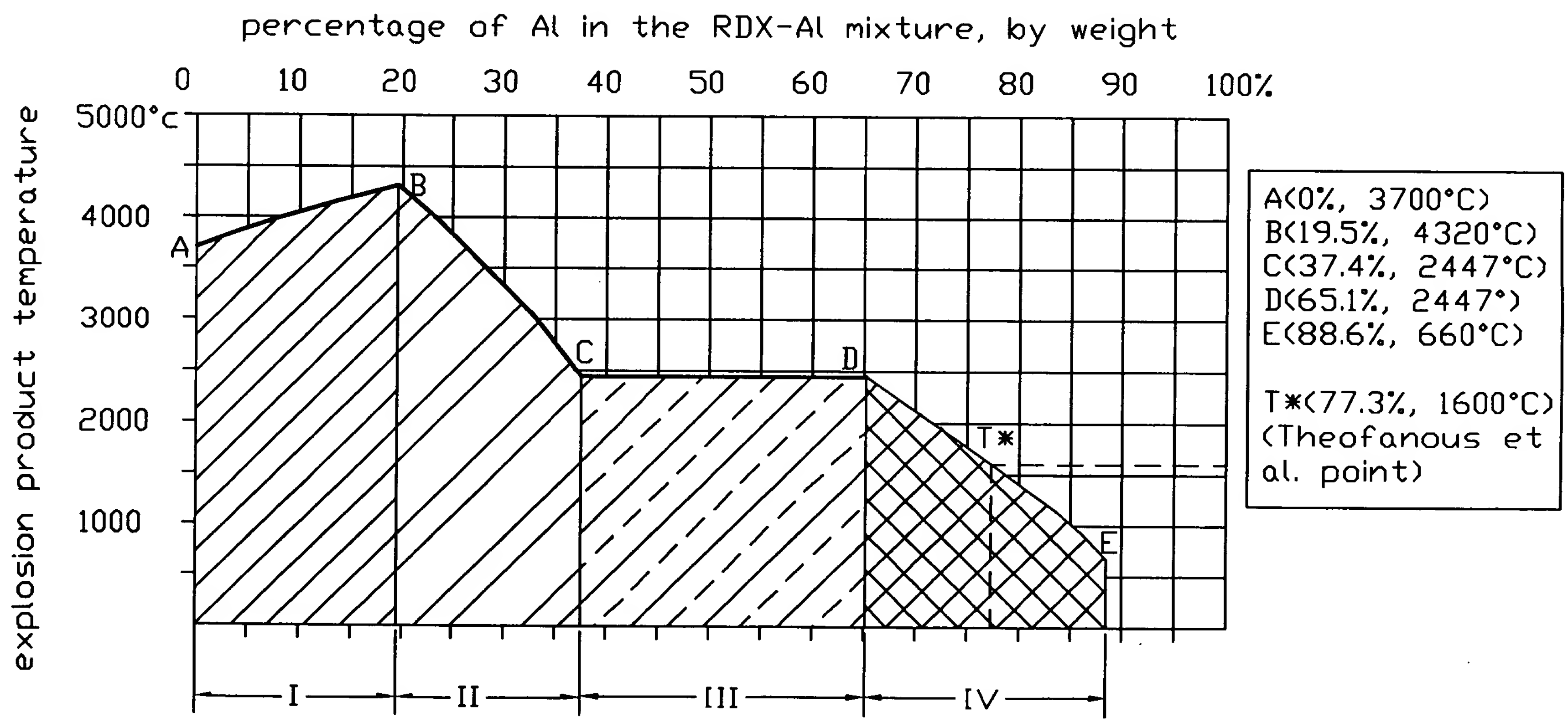
Fig. 1

Equation Number	Chemical Equation	Remarks
EQ 1	$2\ Al + 3H_2O \rightarrow Al_2O_3 + 3H_2 + 946.2$ (KJ/mol)	Explosive event, hydrogen gas produced
EQ 2	$2Al + 3CuO \rightarrow Al_2O_3 + 3Cu + 1203.0$ (KJ/mol)	Non-explosive event, no gaseous product
EQ 3	$C_3H_6O_6N_6 \rightarrow 0.77CO_2 + 2.23CO + 2.23H_2O + 0.77H_2 + 3N_2 + 1145.76$ (KJ/mol)	RDX decomposition by detonation
EQ 4	$2Al + 3CO_2 \rightarrow Al_2O_3 + 3CO + 820.6$ (KJ/mol)	CO_2 as a detonation product
EQ 5	$2Al + 0.77CO_2 + 2.23H_2O \rightarrow Al_2O_3 + 0.77CO + 2.23H_2 + 914.0$ (KJ/mol)	Complete reaction between RDX detonation products and Al
EQ 6	$xAl + 0.385xCO2 + 1.115xH_2O \rightarrow 0.5xAl_2O_3 + 0.385xCO + 1.115xH_2 + 457.0x$ (KJ/mol)	Complete reaction between RDX detonation products and x moles of Al, $0<= x <=2$
EQ 7	$C_3H_6O_6N_6 + xAl \rightarrow (0.77 - 0.385x)CO_2 + (2.23 + 0.385x)CO + (2.23-1.115x)H_2O + (0.77 + 1.115x)H_2 + 3N_2 + 0.5xAl_2O_3 + (1145.76 + 457.0x)$ (KJ/mol)	Complete reaction between 1 mole of RDX and x moles of Al, $0<= x <=2$
EQ 8	$C_3H_6O_6N_6 + xAl \rightarrow 3CO + 3H_2O + 3N_2 + Al_2O_3 + x\ Al + 2060.0$ (KJ/mol)	RDX/Al mixture to produce Al in molten state, $x =>2$
EQ 9	$2Al + 3NH_4NO_3 \rightarrow Al_2O_3 + 6H_2O + 3N_2 + 2023.43$ (KJ/mol)	AN dissolved in water to increase reactivity and to decrease Al temperature for complete chemical reaction
EQ 10	$3CuO + x\ Al \rightarrow Al_2O_3 + 3CuO + (x - 2)Al + 1024.0$ (KJ/mol)	CuO/Al mixture to produce Al in molten state, $x =>2$
EQ 11	$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe + 846.0$ (KJ/mol)	Thermite reaction, mixture used to produce Al in molten state when Al is surplus in stoichiometry

Fig. 2



percentage of Al in the RDX-Al mixture, by weight
0
10
20
30
40
50
60
70
80
90
100%
explosion product temperature
5000°c
4000
3000
2000
1000
A
B
C
D
E
T*
I
II
III
IV
A(0%, 3700°C)
B(19.5%, 4320°C)
C(37.4%, 2447°C)
D(65.1%, 2447°)
E(88.6%, 660°C)
T*(77.3%, 1600°C)
(Theofanous et
al. point)

Fig.3

Name of Oxygen Carrier	Molecular Formula	Oxygen Balance	Solubility in Water	Decomp. Temp.	Remarks
Sodium Nitrate	$NaNO_3$	47% (Na_2O, N_2)	84.5 g/100 ml (20°C)	380°C	Used as oxidizer in propellant, commercial explosives and black powder
Potassium Nitrate	KNO_3	39.6% (K_2O, N_2)	38.5 g/100 ml (25°C)	400°C	Used in pyrotechnics, commercial explosives, black powder, propellants and matches
Barium Nitrate	$Ba(NO_3)_2$	30.6% (BaO, N_2)	8.7 g/100 ml (20°C)	800°C	Used as oxidizer in propellants and pyrotechnics
Ammonium Nitrate	NH_4NO_3	20% (H_2O, N_2)	192 g/100ml (20°C)	210°C	Well-known fertilizer. Used in propellants and commercial explosives
Lithium Perchlorate, LP	$LiClO_4$	60.2% (LiCl)	59.7 g/100ml (25°C)	400°C	Used as oxidizer in rocket and missile propellant
Potassium Perchlorate	$KClO_4$	46.19% (KCl)	18.2 g/100ml (100°C)	530°C	Used as oxidizer in rocket propellant and in explosives
Strontium Perchlorate	$Sr(ClO_4)_2$	44.64% (SrCl)	309.7 g/100ml (25°C)	477°C	Used as oxidizer in propellants
Ammonium Perchlorate	NH_4ClO_4	34.04%	20 g/100ml (25°C)	200~300°C (low temperature decomposition)	Predominantly used as oxidizer in solid propellants for missiles and rockets
Potassium Chlorate	$KClO_3$	39.17%	56.2 g/100ml (100°C)	400°C	Used with fuel to make explosives, also used in pyrotechnics and match head
Sodium Chlorate	$NaClO_3$	45.10%	100 g/100ml (20°C)	melting point 248°C	Moisture absorbing, not very often used in explosives

Fig. 4

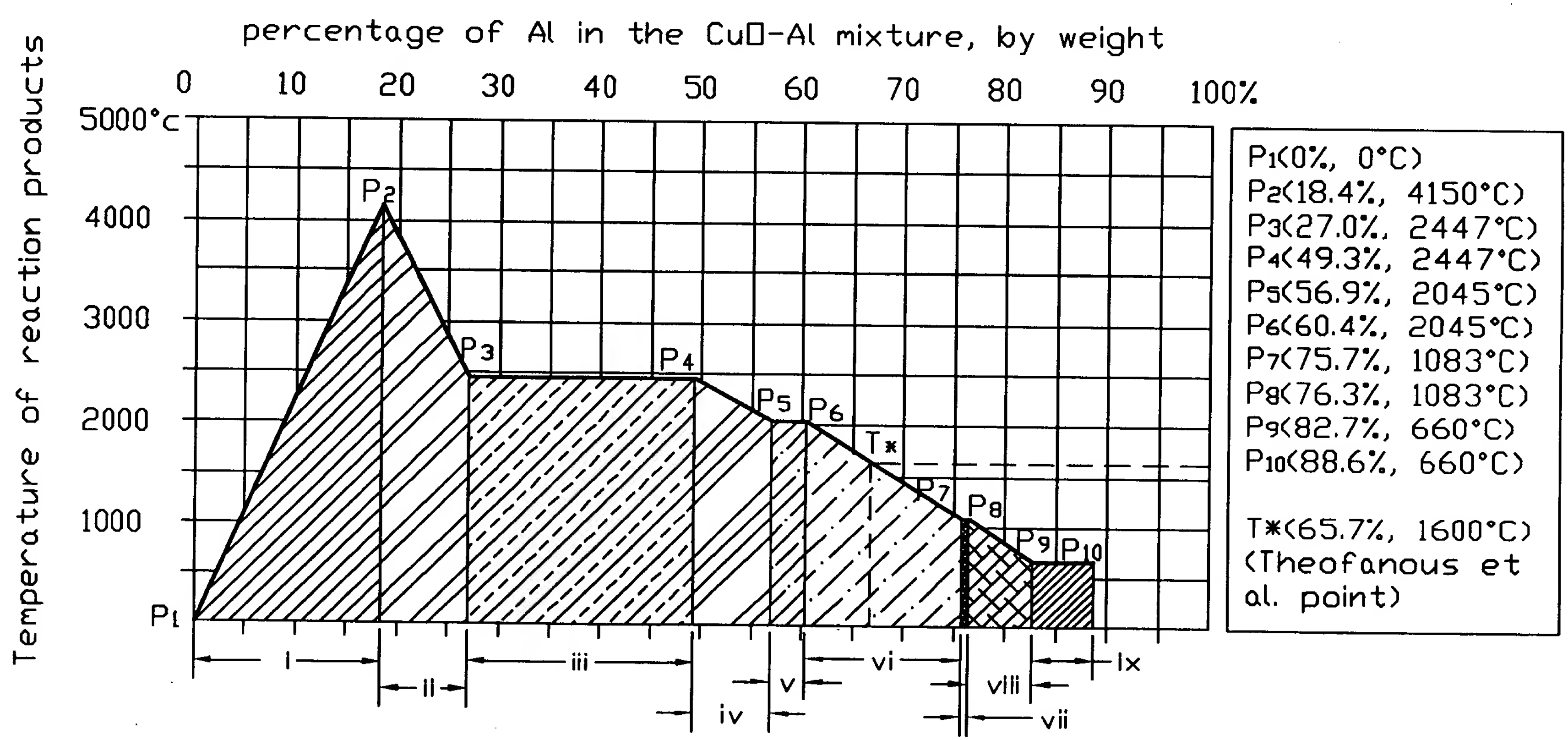

percentage of Al in the CuO-Al mixture, by weight
0
10
20
30
40
50
60
70
80
90
100%
Temperature of reaction products
5000°c
4000
3000
2000
1000
P1
P2
P3
P4
P5
P6
T*
P7
P8
P9
P10
i
ii
iii
iv
v
vi
vii
viii
ix
P1(0%, 0°C)
P2(18.4%, 4150°C)
P3(27.0%, 2447°C)
P4(49.3%, 2447°C)
P5(56.9%, 2045°C)
P6(60.4%, 2045°C)
P7(75.7%, 1083°C)
P8(76.3%, 1083°C)
P9(82.7%, 660°C)
P10(88.6%, 660°C)
T*(65.7%, 1600°C)
(Theofanous et al. point)

Fig. 5

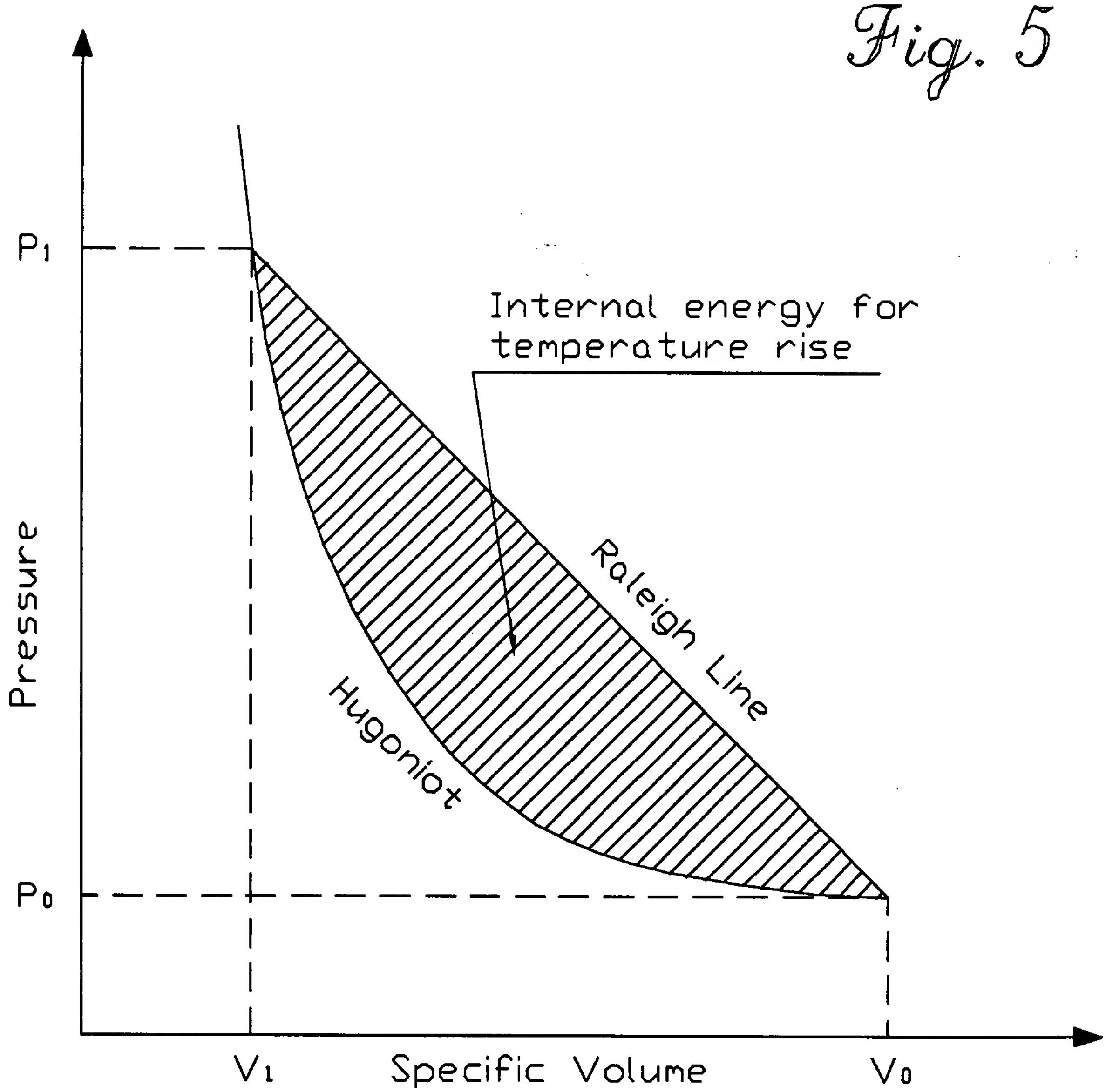

Pressure
P1
P0
Internal energy for
temperature rise
Raleigh Line
Hugoniot
V1
Specific Volume
V0

Fig. 6

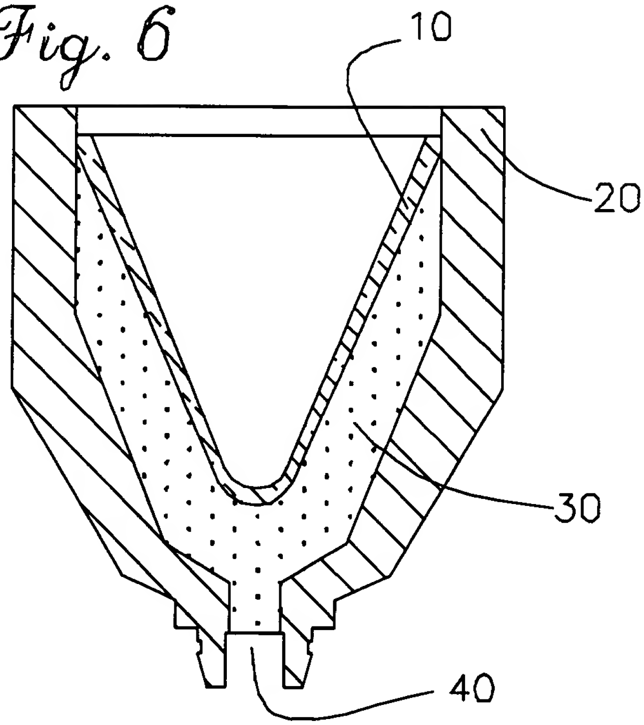


Fig. 7

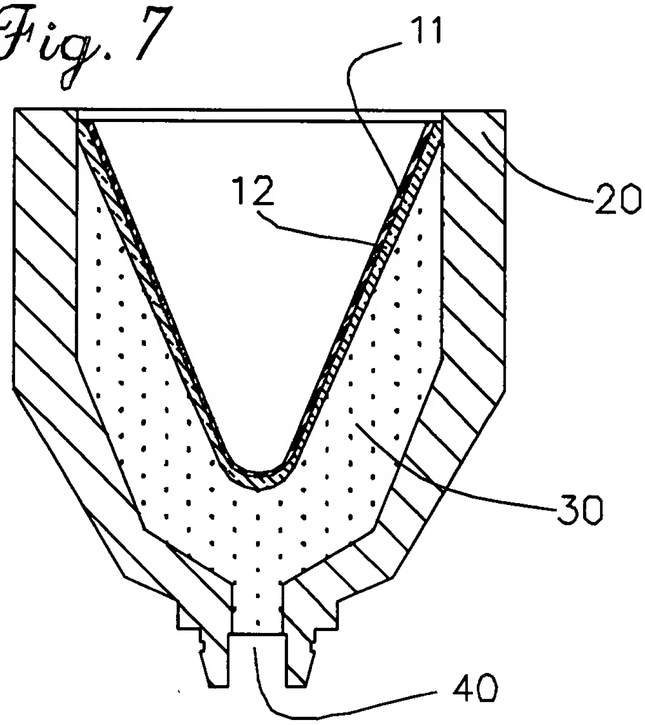


Fig. 8 (a) (b)

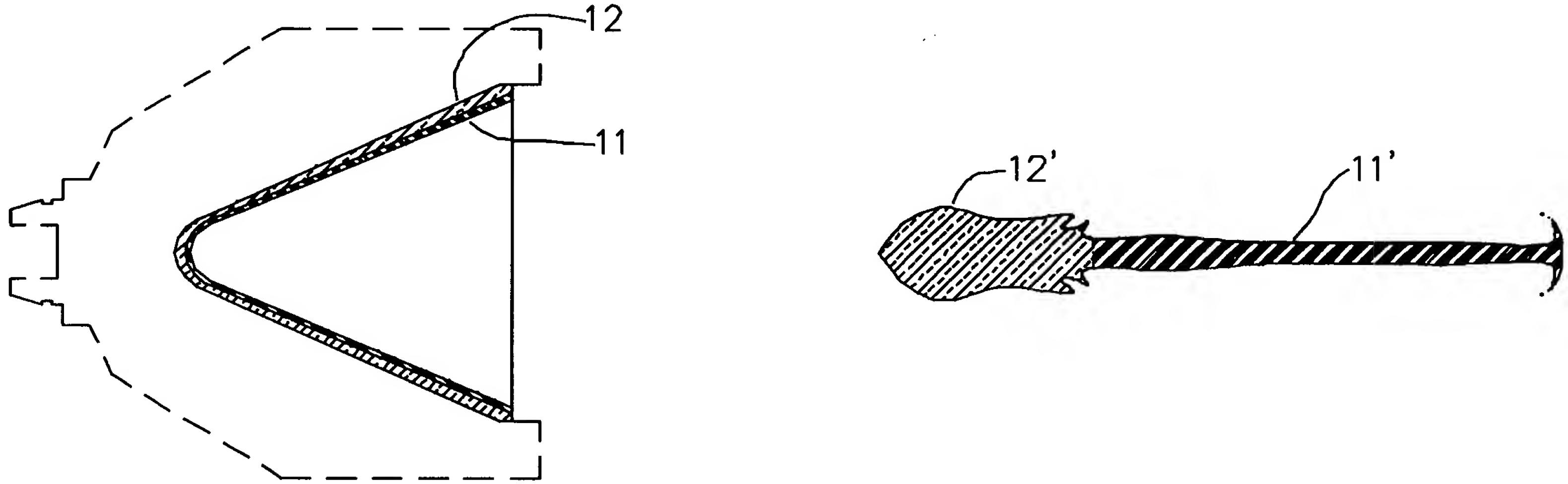


Fig. 9

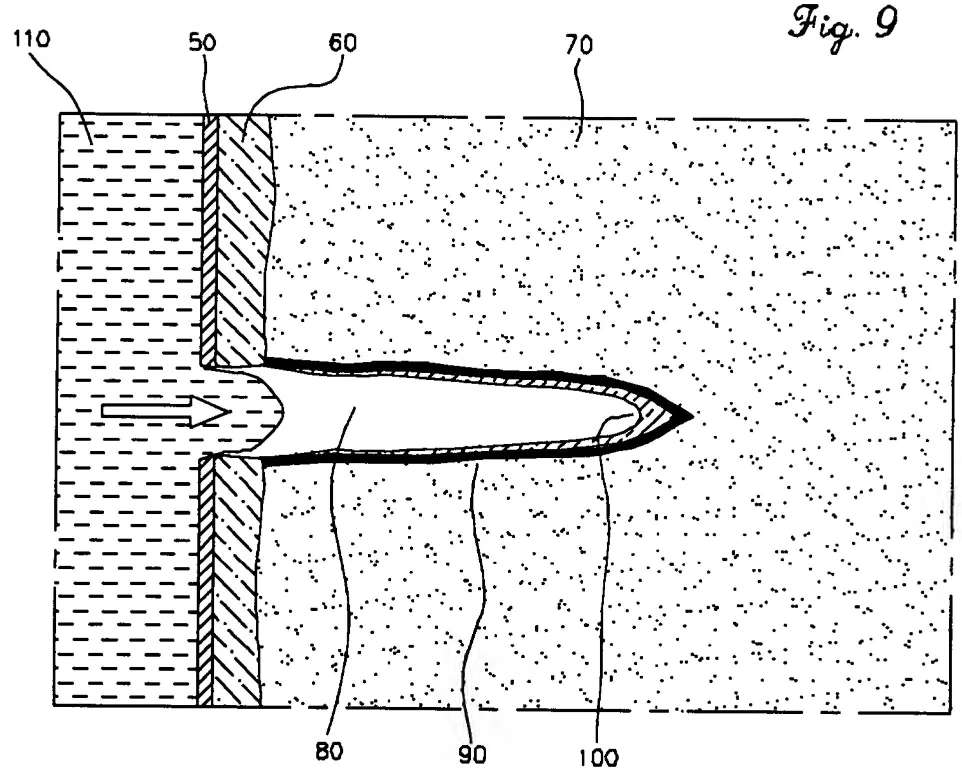


Fig. 10

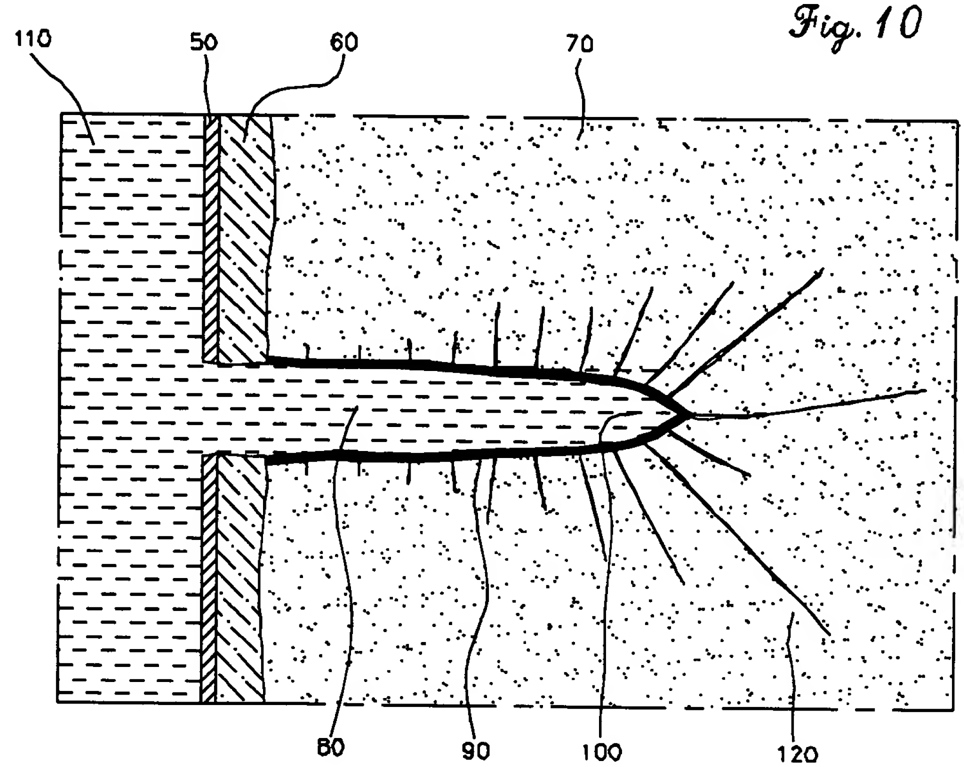


Fig. 11

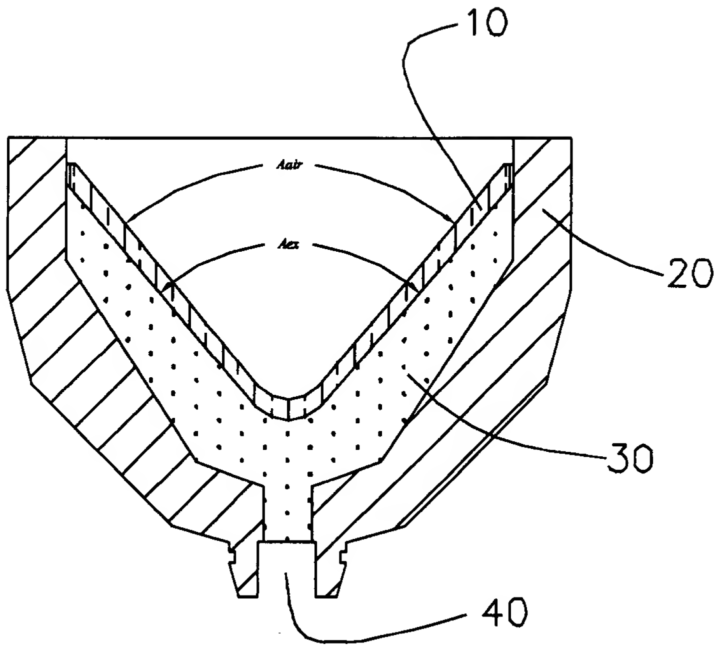


Fig. 12

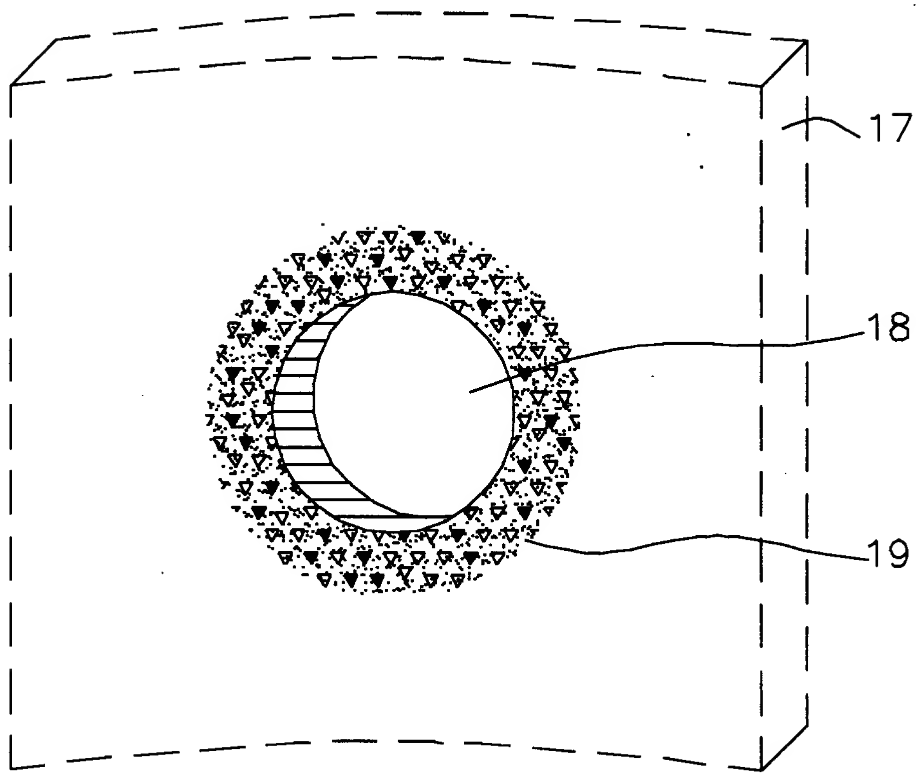


Fig. 13

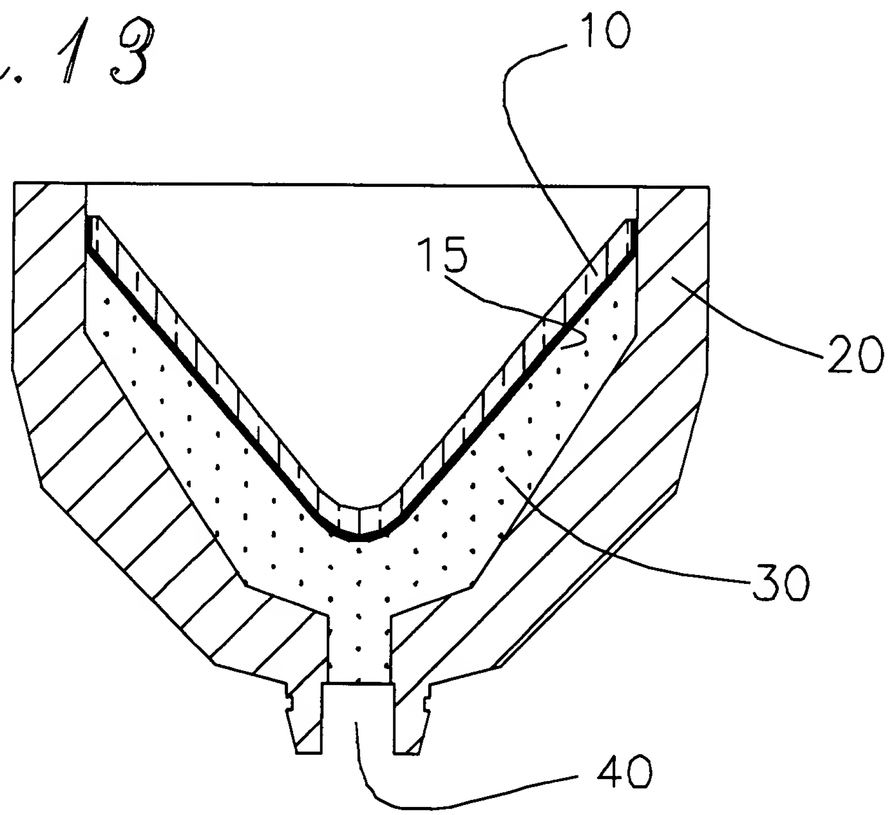
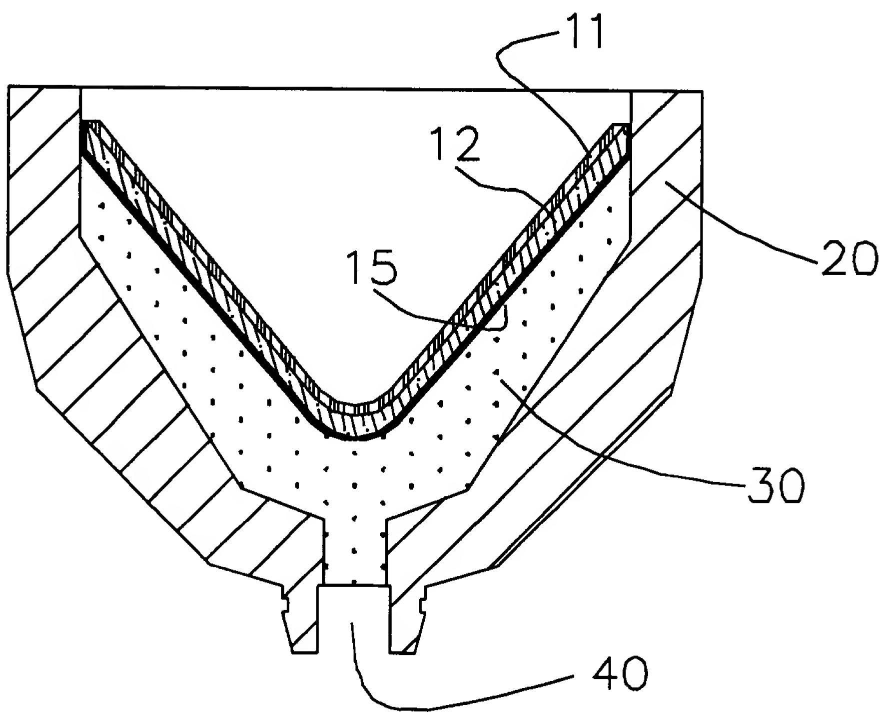


Fig. 14



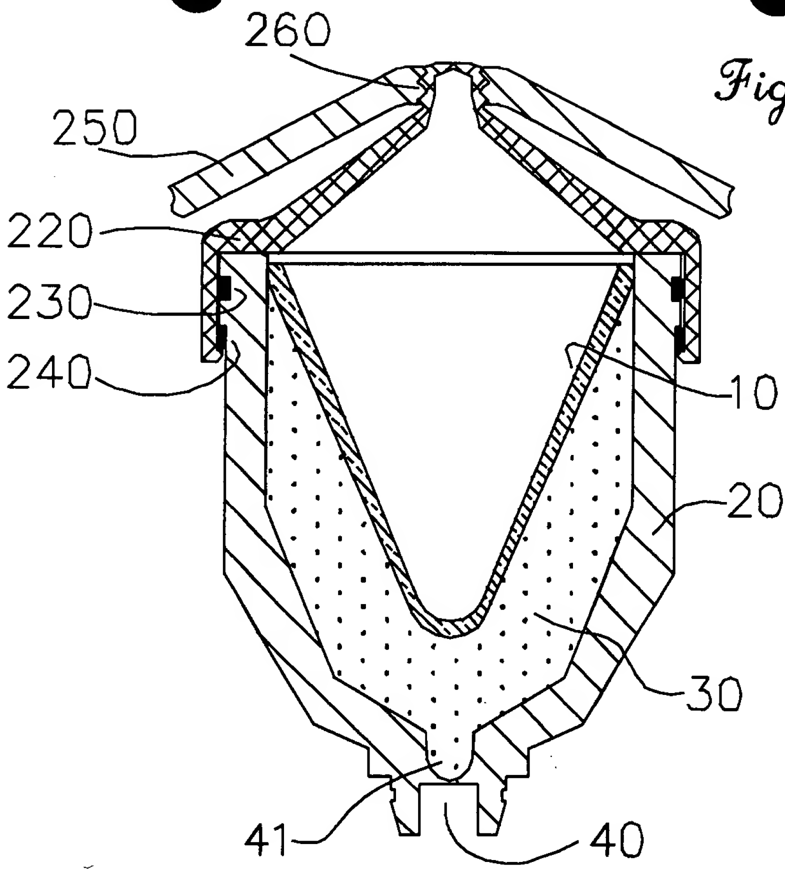

260
250
220
230
240
10
20
30
41
40

Fig. 15

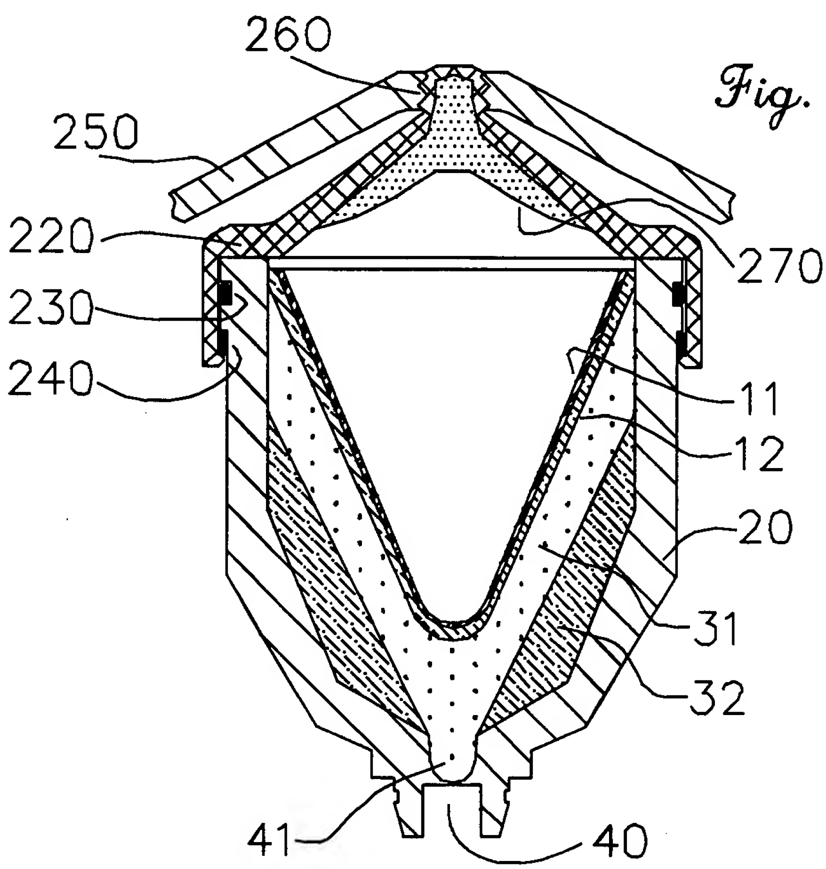

260
250
220
270
230
240
11
12
20
31
32
41
40

Fig. 16

Fig. 17

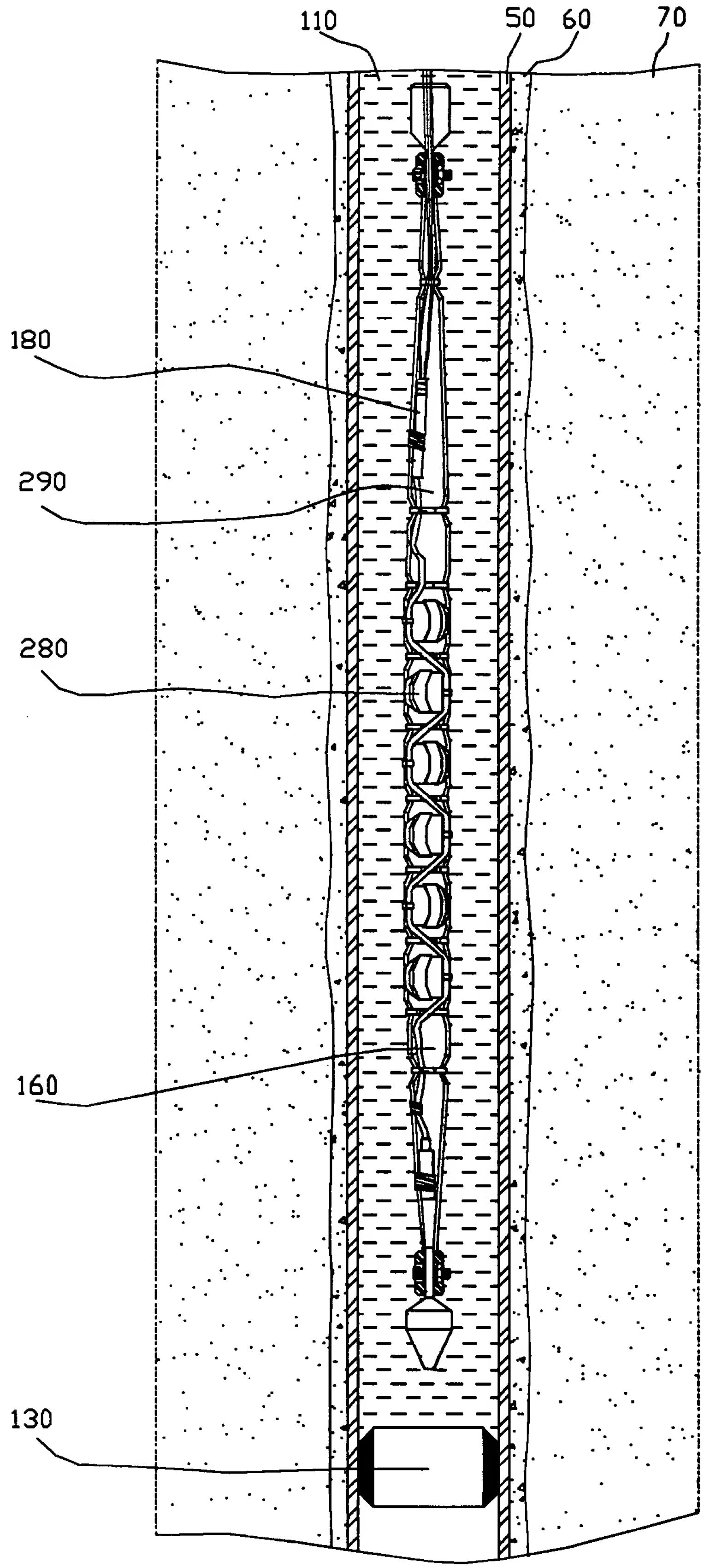


Fig. 18

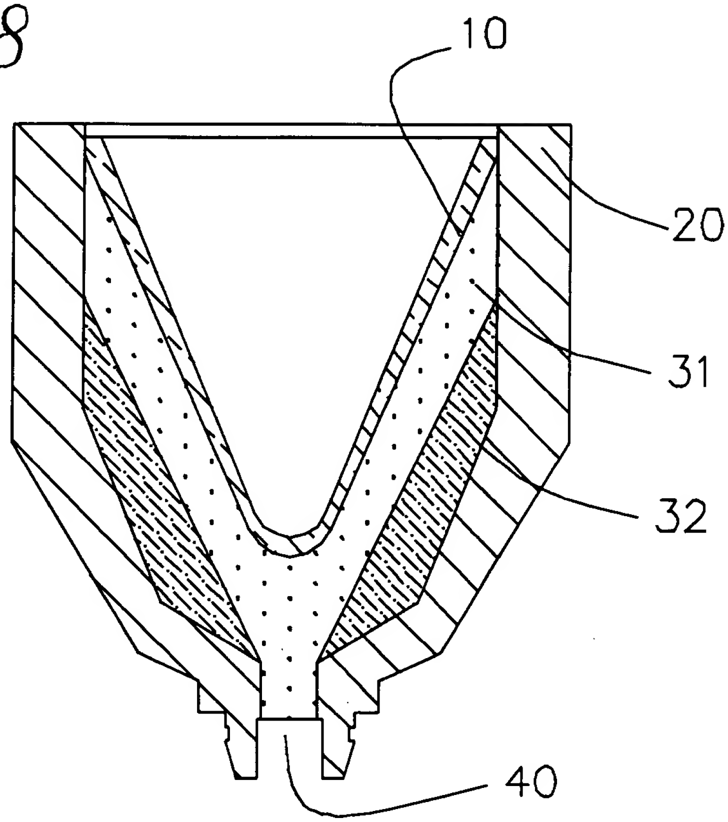


Fig. 19

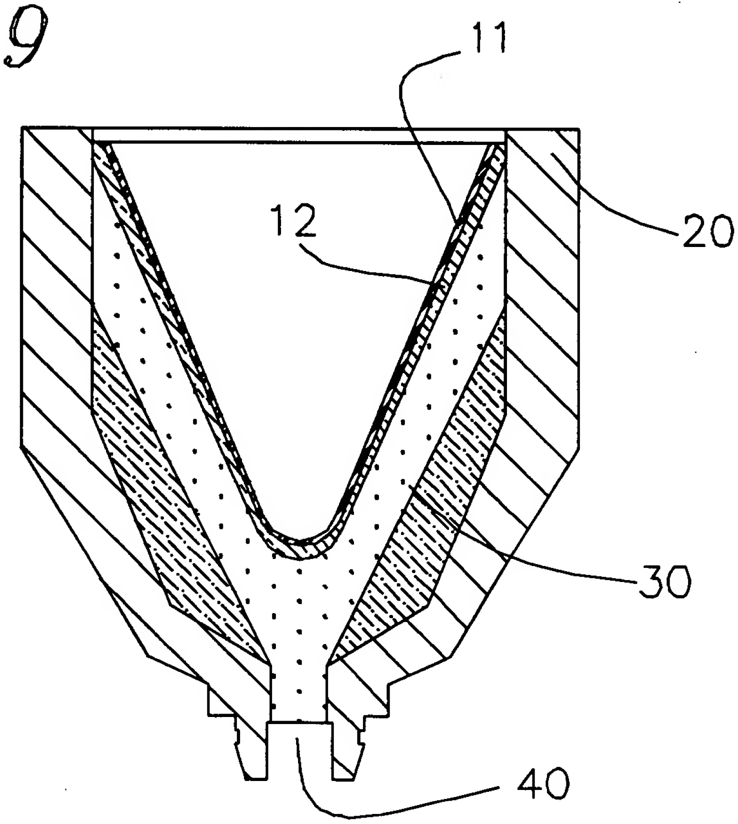


Fig. 20

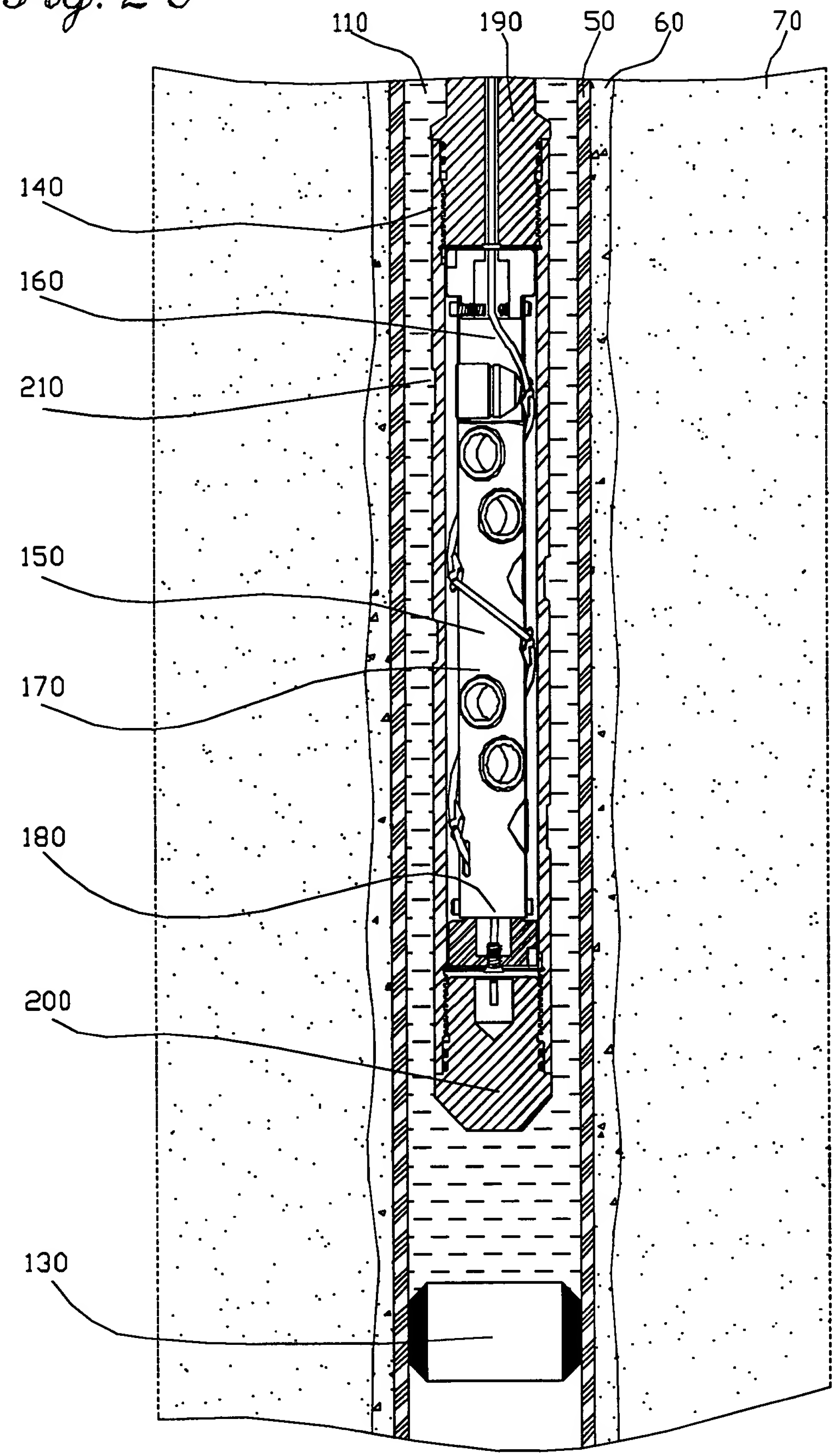


Fig. 21

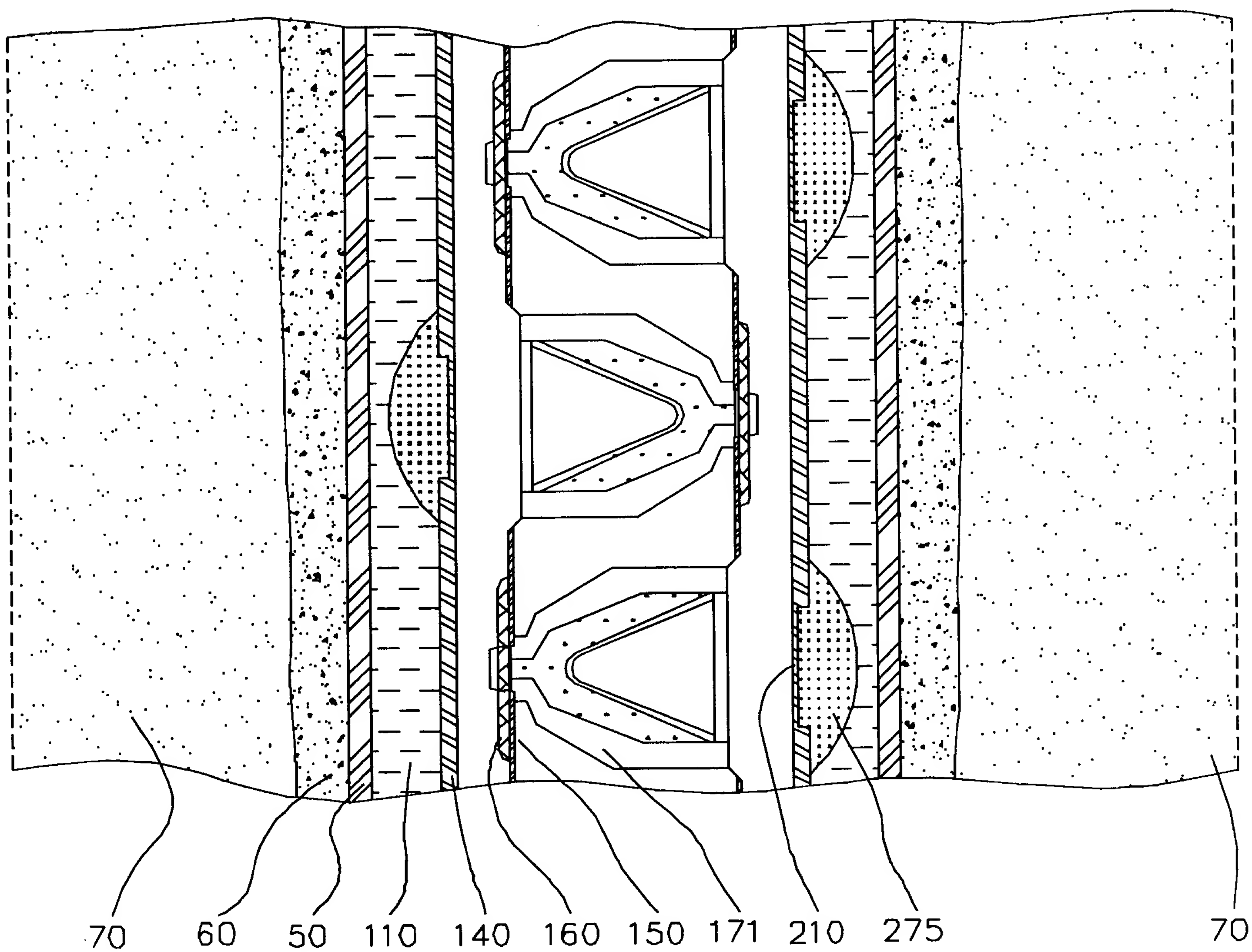


Fig. 22

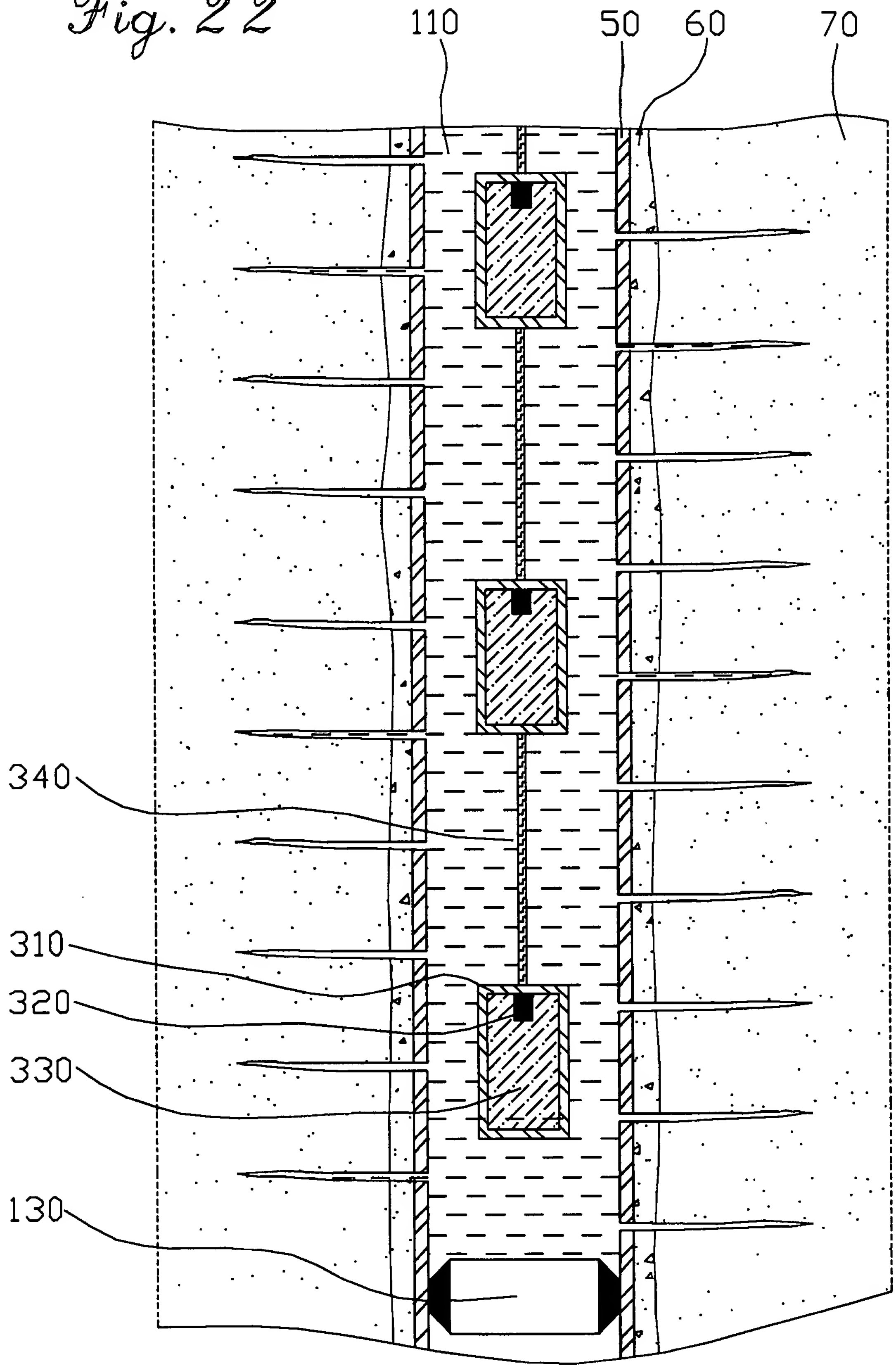


Fig. 23

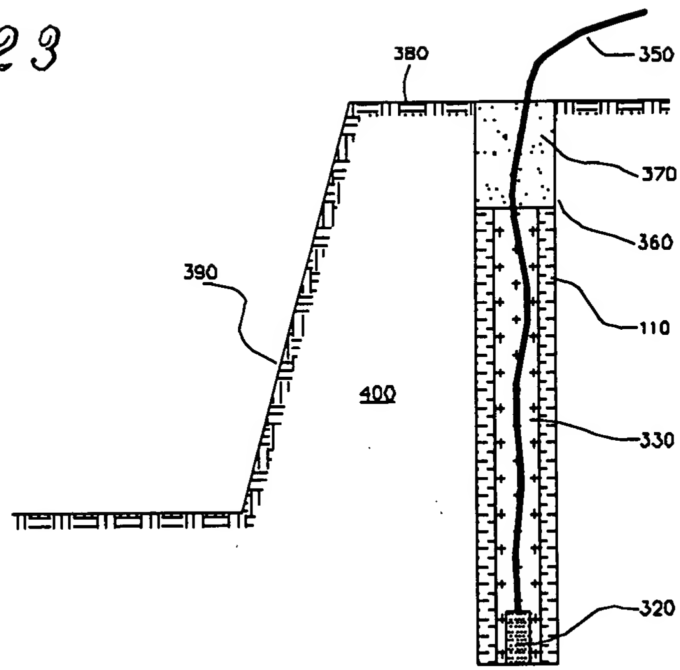
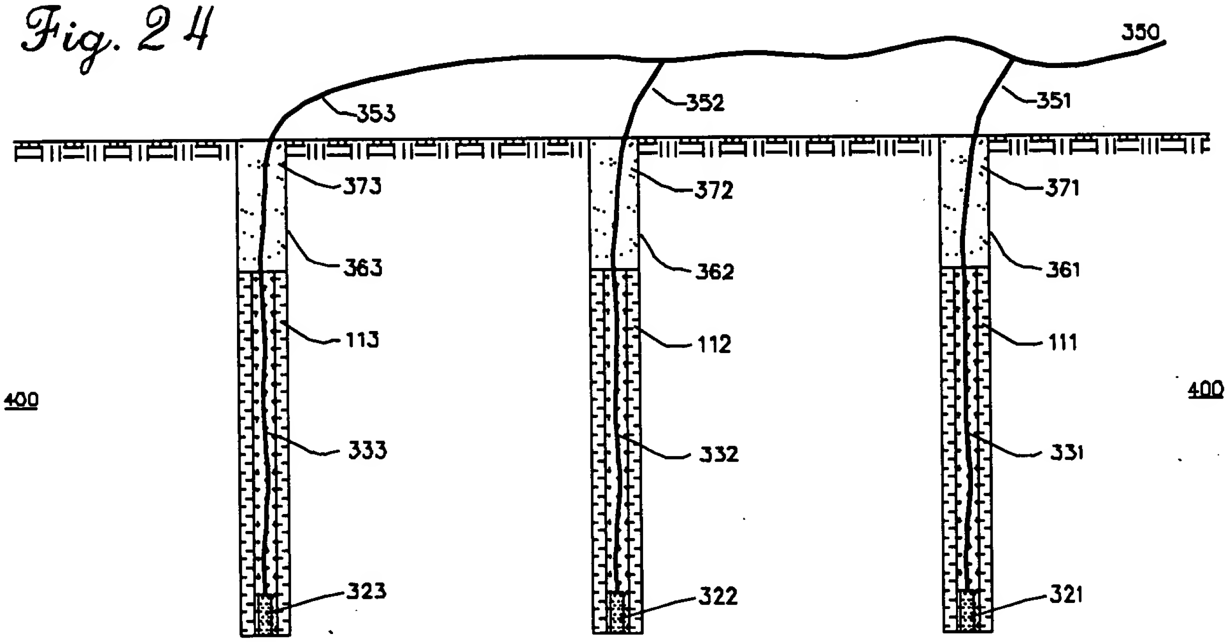

380
350
370
360
390
110
400
330
320

Fig. 24


350
353
352
351
373
372
371
363
362
361
113
112
111
400
400
333
332
331
323
322
321